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Prognostic factors in mechanically ventilated patients

Prognosis in ventilation

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Abstract

Aim: In this study, we aimed to investigate the prognostic values of respiratory parameters recorded within the first 48 hours in patients connected to mechanical ventilation in the intensive care unit (ICU), in terms of 30-day mortality. Material and Method: This prospective study included patients who received mechanical ventilation due to acute respiratory failure between 2011 and 2013. The demographic characteristics of the patients, Glasgow Coma Score (GCS) scores, Acute Physiology and Chronic Health Evaluation II (APACHE II) and Sequential Organ Failure Assessment (SOFA) values, vital signs, the results of complete blood count, biochemistry parameters and blood gas analyses were recorded. Patients were divided into two groups as survivors and non-survivors, and the differences in the parameters between the groups were analysed. Results: The study included 99 mechanically ventilated patients with the mean age 71.73 (18-105) years. Of the patients, 56 (56.6%) were male and 43 (43.4%) were female. Comparison of the survivors (n=37) with the non-survivors (n=62) indicated that the non-survivors had no statistical differences in terms of age, gender, or concomitant diseases. The values of GCS, APACHE II, and SOFA were significantly different between survivors and non-survivors (for all, p<0.001). Significant differences were also noted in FiO2 (p<0.001), pH (p=0.001), PO2 (p=0.044), PCO2 (p=0.046), A-a Gradient (p<0.001) and the expected increase of O2 gradient (p=0.026) between two groups. Discussion: Our findings indicate that, during the follow-up of the mechanically ventilated patients, respiratory parameters measured within the first 48 hours are cheap and easy-to-use parameters to predict the prognosis.

Keywords

Intensive Care; Mechanical Ventilation; Prognosis; Blood Gases; Scoring

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Introduction

Contrary to the common belief, intubation and mechanical ventilation are not recent discoveries. Their roots are as old as modern science. However, mechanical ventilation became available at the beginning of the 20th century [1]. Its widespread applications started during the North European polio outbreak in the 1950s.

Drinker suggested that these patients could be saved by providing respiratory support in the paralytic period. He developed the "Iron Lung", which worked with negative pressure similar to the normal respiratory physiology. The little girl, who was the first polio patient to receive mechanical ventilation via the "Iron Lung", even wanted an ice-cream after mechanical ventilation was withdrawn after four hours, but she eventually died due to pneumonia. Despite its short-term success, patients died in the long term due to "Tank Shock" which caused abdominal vascular ponding and low cardiac output. Consequently, this technique was replaced by ventilation that works with positive pressure. Dr. Bjorn Ibsen, who observed this situation attentively and systematically, noticed that many patients died due to inadequate ventilation during the polio epidemics. He reduced the mortality rate from 85% to 15% by providing only close and intense follow-up, sedation, monitoring, proper airway ventilation with positive pressure at intervals and aspiration of secretions. Following such a sharp drop in the mortality rate, ideas to form units that are reserved for the care of patients who are connected to mechanical ventilation, which are now known as "Intensive Care" units, emerged. For this reason, mechanical ventilation is the core of intensive care units and their reason for being [1,2].

Material and Methods

The present study was carried out in the emergency unit of the emergency medicine department of a tertiary university hospital between November 2011 and October 2013. All procedures performed in the studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Ethics committee approval was received for this study from the ethics committee of local University. All the participants who are legally responsible or first-degree relatives of the patient in the study gave their informed consent prior to the commencement of the research. Written informed consent was obtained from the patient's legal custodian or first-degree relatives of the patient for publishing the individual medical records.

Study population

A total number of 99 consecutive patients, 27 of which constituted the control group and 72 of which were connected to MV in the emergency critical intensive care unit of a tertiary university hospital due to acute respiratory failure between November 2011 and October 2013, were included to this prospective study. Patients with congestive heart failure, cardiomyopathy, patients who recently had a myocardial infarction, patients under the age of 18 years, patients with a neuromuscular disease and pregnant patients were excluded from the study.

Study protocol

The demographic characteristics, Glasgow Coma Score (GCS) scores, Acute Physiology and Chronic Health Evaluation II (APACHE II) and Sequential Organ Failure Assessment (SOFA) values, vital signs, CBC, biochemical parameters and blood gas levels of the patients were analysed. Glasgow coma scale score was recorded. For APACHE II and SOFA, the scores were calculated by taking the worst parameters recorded within the first 48 hours into account. Although the criteria defined by Christie HA et al. were used in order to start MV, these criteria alone were not considered as the definite indication [3]. The decision to start MV was given by taking not only the respiratory factors but also the specific clinical factors relevant to other body systems into consideration, especially circulatory, central nervous and hemopoietic systems. Synchronized Intermittent-Mandatory Ventilation (SIMV) mode was used as the start mode in patients connected to mechanical ventilation. Other parameters were adjusted by treating physicians individually for each patient. When deemed necessary, patients were sedated at the onset of mechanical ventilation.

Statistical analysis

All data were transferred into Statistical Package for Social Sciences version 18 (SPSS v18) (IBM Corp., Chicago, IL, USA). The package software was used for data analysis. For the assessment of mortality, statistical analysis of normally distributed numeric data was performed by the Student's T-test; data that did not fit the normal distribution were analysed by the Mann-Whitney U Test. Patients were divided into two groups as the survivors and the deceased, and the differences between two groups were analysed for all parameters. The confidence interval was considered as 95% in all statistical analyses and p-values < 0.05 (two-way) were accepted statistically significant.

Results

A total number of 99 patients with a mean age of 71.73 years (range: 18-105 years) were included in the study. Fifty-six of them (56.6%) were male and 43 (43.4%) were female. The patients were assessed based on the data collected within the first 48 hours and on the 30th day (Table 1). When the patients who survived (n=37) and who died (n=62) were compared, no significant difference was detected in 30-days mortality based on age (p=0.092), gender (p=0.697), or concomitant diseases (p=0.283) (Figure 1). Differences between GCS (p<0.001), APACHE II (p<0.001) and SOFA (p<0.001) scores were significant (Figure 2). In terms of respiratory parameters, FiO2 (p<0.001), pH (p=0,001), PO2 (p= 0,044), PCO2 (p=0,046) (Figure 3), A-a Gradient (p<0.001) and the expected O2 gradient differences (Figure 4) were statistically significant between two groups.

Discussion

Patients who cannot be treated by conventional methods, patients who lost organ functions due to severe disease progression or patients with a disease associated with a high mortality rate are monitored and treated in the ICUs. MV is commonly used in the ICUs [4]. With the increasing life expectancy worldwide, it causes a high rate of chronic diseases. Up to 20 million people worldwide are admitted to ICUs and require MV [5]. Only 30.000 patients undergo mechanical ventilation in the United Kingdom and 500.000 in the United States annually. [6,7]. In the United States, ICU care is approximately four times more expensive compared to the regular care provided in the hospital wards [4]. The incidence may even differ between countries and even between regions in the same country. The extent of the

Table 1. Comparison of parameters in terms of 30-day mortality

		Survivors (n=37)	Non-survivors (n=62)	P value
Age		67.97 ± 19.48	73.97 ± 10.98	0.092
Gender	Male	20 (54.1%)	36 (58.1%)	0.697
	Female	17 (45.9%)	26 (41.9%)	
Comorbidity	No	3 (8.1%)	2 (3.2%)	0.283
	Yes	34 (91.9%)	60 (96.8%)	
Sedation	No	31 (83.8%)	48 (77.4%)	0.445
	Yes	6 (16.2%)	14 (22.6%)	
GCS		12.70 ± 3.30	8.73 ± 4.59	<0.001
APACHEII		17.38 ± 5.29	26.52 ± 6.56	<0.001
SOFA		4.49 ± 3.00	8.31 ± 2.96	<0.001
Temperature		36.71 ± 0.64	36.82 ± 0.68	0.510
Pulse		99.70 ± 26.46	103.39 ± 28.42	0.415
MAP		86.25 ± 20.99	74.58 ± 19.68	0.008
Hb		11.11 ± 2.74	11.68 ± 2.0228	0.279
Htc		33.96 ± 8.21	36.90 ± 6.26	0.066
Plt		223.31 ± 94.376	213.18 ± 99.182	0.618
Urea		77.86 ± 54.23	99.17 ± 67.75	0.060
Creatinine		1.60 ± 1.36	1.81 ± 1.12	0.024
Na		138.54 ±4.75	138.64 ± 6.05	0.933
K		4.31 ± 0.78	4.75 ± 1.10	0.052
AST		32.69 ± 20.58	301.92 ± 1159.21	<0.001
ALT		22.36 ± 15.66	237.26 ± 873.59	0.002
Bilib		1.45 ± 2.98	1.64 ± 1.50	0.013
FiO_2		42.65 ± 22.56	70.69± 26.69	<0.001
pH		7.35 ± 0.09	7.27 ± 0.13	0.001
PO_2		92.27±36.37	82.38±42.03	0.044
PCO_2		34.64±14.91	41.22±19.00	0.046
A-a Gradient		344.89±108.93	387.84±121.05	<0.001
Expected difference		19.42 ± 4.12	21.87 ± 2.73	0.026

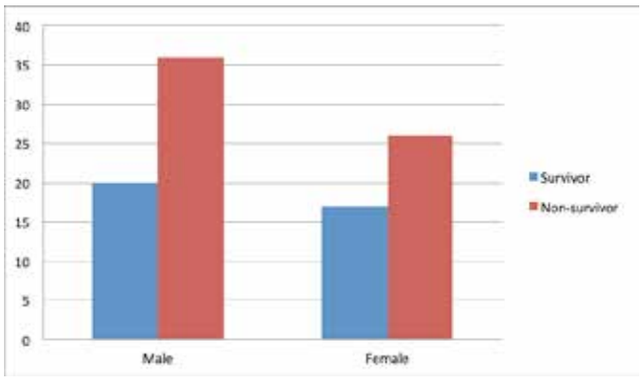

Figure 1. Gender differences in 30-day mortality

incidence rate is bound to local risk factors such as etiology prevalence, equipment and the number of intensive care units. High incidence can be seen in countries with high ICU bed capacity and populations at risk. [6,7].

MV is "a necessary evil", a lifesaving treatment but with important potential complications, it can cause or deteriorate lung damage through mechanisms such as barotrauma, volutrauma or atelectrauma, which is also called ventilator-associated lung injury and represents the human counterpart of the ventilator-induced lung injury observed in lab animals [8,9]. In addition to giving direct structural damage, these mechanical forces can trigger a local and systemic inflammatory response (biotrauma)

Figure 2. APACHE II, GCS, SOFA scores for 30-day mortality

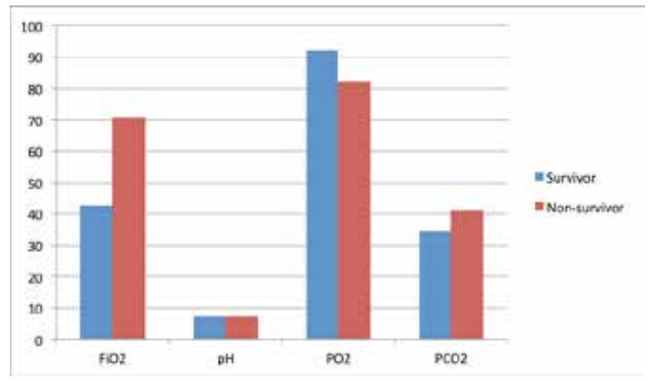

Figure 3. Comparison of FiO2, pH, PO2, PCO2 in terms of 30-day mortality

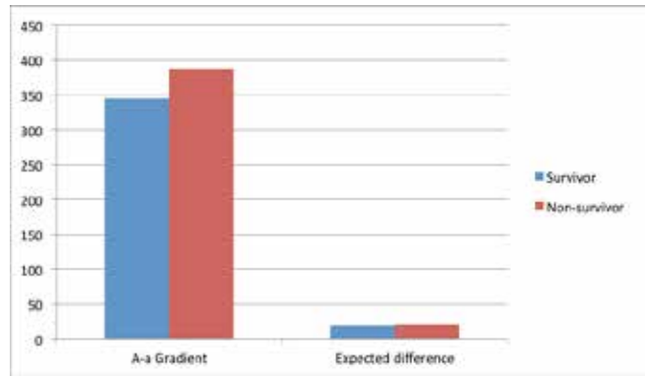

Figure 4. Comparison of A-a Gradient and expected difference in terms of 30-day mortality

and a series of complex inflammatory mediators, which result in multiple organ system dysfunctions and eventually cause death [10]. The lung is the first organ to show signs of failure and this failure is a reason to start or continue MV [11]. Mortality among these patients depends on many factors. It is difficult to estimate the prognosis in a patient only based on certain parameters, if the patient has concomitant cardiovascular, renal, haematological, neurological or infectious complications, all of which strongly affect the prognosis [12].

Intensive care scoring systems are used to estimate the recovery and severity of the disease and the level of organ dysfunction, to evaluate treatment outcomes, to standardize the patient care and to compare the performances between intensive care units [13]. For this purpose, patient data obtained from daily specific measurements are used. Scoring systems are divided into two groups: prognostic (estimates mortality) and organ failure scoring systems (measures morbidity). However, the level of organ failure is not only related to morbidity, but it

also has a considerable correlation with mortality [14]. Scoring systems that assess both mortality and morbidity were used in our study. The factors that determine the mortality in intensive care patients include the patients' physiological reserve, type, and severity of their disease, and their response to the treatment. Moreover, chronological age and chronic disorders can affect patients' physiological reserve by impairing functions of organ systems. The severity of the disease can be evaluated according to the anatomical trauma or through functions [14].

According to the current epidemiologic studies, the median age of patients who receive mechanical ventilator support, 40% of which are women, is 63 years (48-73 years) [15]. In our study, the median age was 74 years (18-105 years), higher than the literature. Similarly, the percentage of male patients was slightly higher than the literature with 56.6% and the percentage of female patients was slightly lower with 43.4%. This trend appears to continue in the future. The reason for the use of MV was a postoperative respiratory failure in most of the patients (65%), followed by traffic accidents in the literature [15]. Traffic accidents, the most frequent cause of hospitalization and MV are anticipated to increase by 65% until 2033 in developing countries. For this reason, it seems certain that we will encounter more MV in the coming years [6,7]. In our study, only an 18-year-old patient received mechanical ventilation following a motorcycle accident. The remaining 71 patients received respiratory support due to secondary respiratory failure. The lack of postoperative respiratory failure can be attributed to the monitoring of these patients by the intensive care units of surgical clinics and by reanimation clinics.

The rate of mortality on MV as reported by previous studies varied between 34 and 81%. The rate of 30-day mortality was not significantly different between the survivors and non-survivors based on age, gender or concomitant diseases. Consistent with the literature, age was shown to be an important factor determining in-hospital mortality among older intensive care patients, but it was not sufficient alone. The mean age of survivors was 5 years lower than that of non-survivors. Also, it was demonstrated in the literature that concomitant diseases also affect the rate of mortality, but we could not detect a significant difference in 30-day mortality rate based on concomitant diseases. In terms of respiratory parameters, FiO2 (in survivors 42.6 ± 22.5; in non-survivors 70.6± 26.6 p<0.001), pH (in survivors 7.35; in non-survivors 7.27 p=0.001), PO2 (in survivors 92.2±36.3; in non-survivors 82.3±42 p= 0.044) , PCO2 (in survivors 34.6±14.9; in non-survivors 41.2±19 p= 0.046), A-a Gradient (in survivors 344.8±108.9; in non-survivors 387.8±121 p<0.001) and the expected O2 gradient (in survivors 19.4 ± 4.1; in non-survivors 21.8 ± 2.7 p= 0.026) differences were statistically significant (Table 1). In other words, within the first 48 hours of ventilation, the mortality rate was high among the patients receiving high concentrations of O2, patients with a high O2 gradient and difference. We could not determine a similar relation in the literature. In addition, our study planned between November 2011 and November 2019 has been going on.

Like any study, our study has some limitations. The first point is that it is a single-center study and a tertiary step, relatively limited and low number of patients, non-gender equality, a short period of time, and the common point in almost all studies conducted in our country is lack of knowledge about the long term results of the patients due to lack of follow-up and medical records. In particular, the prospective nature of the study and potential for era bias can be considered limitations.

We have learned a lot about intensive care since Dr. Bjorn Ibsen's time. Scoring systems and parameters are surplus, complex, and usually difficult to learn and practice. This mandates us to search for parameters that are easy to learn and practice. There's so much we have to learn. There is a large, multicentre, multinational wide scientific research lack of MV. These researches should be promoted and supported. We believe that new parameters will contribute to the evaluation, monitoring, and treatment of MV patients. In conclusion, in the follow-up of patients receiving MV, A-a Gradient and expected O2 gradient difference values are inexpensive and easy-to-use parameters to predict the prognosis based on data recorded within the first 48 hours.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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